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a minimum; like results hold for more than three variables. This is a direct generalization of the standard deviation method of comparing different distributions and yields a unique equation of relation between a variable as opposed to the usually inconsistent regression equations of the Pearson method. A short process for obtaining a first approximation for the best line or plane was given.

9. In this paper Prof. Hancock showed if  $c_2 = (k^2 + l^2)[1 - m^2 - p^2]$ ,  $c_1 = mk + pl$ ,  $b_1 = k + p(ml - pk)$ ,  $a_1 = l + m(pk - ml)$ ,  $b_2 = [(ml - pk)^2 - k^2][1 - m^2 - p^2]$ ,  $a_2 = [(pk - ml)^2 - l^2][1 - m^2 - p^2]$ , ( $k, l, m, p$ , arbitrary rational integers), be written in the equations:  $x^2 - 2a_1x - a_2 = 0$  ( $a_1, a_2$  rational integers),  $y^2 - 2b_1y - b_2 = 0$  ( $b_1, b_2$  rational integers),  $z^2 - 2c_1z - c_2 = 0$  ( $c_1, c_2$  rational integers), the roots of these three equations, *i.e.*, the algebraic quadratic integers  $\xi, \eta, \zeta$ , say, satisfy the equation  $\xi^2 + \eta^2 = \zeta^2$ .

10. Prof. Moore presented a statement concerning the aims and progress of the reports of the National Committee on Mathematics Requirements. The succeeding discussion, by Mr. Boldt and Miss Gule, dealt chiefly with the report on junior high school mathematics. In the succeeding general discussion, Prof. Weaver, speaking from experience in vocational and other schools, appealed for attention to the preparation of teachers as well as of students. Prof. Wildermuth emphasized the necessity of holding students to strict account for the work assigned; Professor Kuhn related his experiences with beginning junior high school mathematics in his own family. Further participants in the spirited discussions were Professors Beatty, Bennett, Rasor, and Dustheimer, and Supt. Collicott, and Miss Amy F. Preston of the Columbus Schools.

G. N. ARMSTRONG, *Secretary-Treasurer*.

## NEW INFORMATION RESPECTING ROBERT RECORDE.

By DAVID EUGENE SMITH, Columbia University.

Our knowledge of Robert Recorde, the first mathematician of any note to publish works in the English language, is very meager. In general, recent writers have trusted to the books which he wrote and to various biographical notes that have appeared,—the former affording evidence of undoubted value, but the latter being little more than tradition.

Recorde's tombstone in the parish church at Tenby, Pembrokeshire, might be expected to be of assistance, but it turns out to be a modern one, affording no information of value. The inscription is as follows (compare the frontispiece):

IN MEMORY OF  
ROBERT RECORDE,  
THE EMINENT MATHEMATICIAN,  
WHO WAS BORN AT TENBY, CIRCA 1510.  
TO HIS GENIUS WE OWE THE EARLIEST  
IMPORTANT ENGLISH TREATISES ON  
ALGEBRA, ARITHMETIC, ASTRONOMY, AND GEOMETRY;  
HE ALSO INVENTED THE SIGN OF

EQUALITY = NOW UNIVERSALLY ADOPTED  
 BY THE CIVILIZED WORLD.  
 ROBERT RECORDE  
 WAS COURT PHYSICIAN TO  
 KING EDWARD VI. AND QUEEN MARY.  
 HE DIED IN LONDON,  
 1558.

It is well known that Recorde was a student at Oxford, becoming a fellow of All Soul's College in 1531. In 1545 he received the degree of M.D. at Cambridge, and he is known to have taught mathematics in private classes, at both Oxford and Cambridge, prior to going to London as physician to Edward VI and Queen Mary. Roger Ascham was the Latin secretary to both the king and the queen at about that time, and it is probable that Recorde's ideas of textbook making were received in part from this great educator. Of the mathematical works which he seems to have written, only four were published.<sup>1</sup> These are well known and need not be mentioned in this connection.

A number of years ago the Reverend Done Bushell, rector at the Harrow School, purchased at a sale in Harrow a small portrait on an oak panel about 12 inches by 14 inches in size. The painting is apparently the work of a sixteenth century artist and is much dimmed by age. In the upper left-hand corner there is the inscription:

"Rob.<sup>t</sup> Record. M.D.  
 1556."

although this is so dim from age as not to show in the photographic reproduction given in the frontispiece.

As to the authenticity of the painting there can be no question. The spelling of the name is not unusual, Recorde sometimes using the final "e" and sometimes not. He was not a man of such prominence that his portrait would be painted after his death, and all the evidence goes to show that we have here an authentic painting from life, made in the year 1556, and the only portrait painting known.<sup>2</sup> This portrait is now reproduced by the courtesy of the present owner, W. F. Bushnell, Esq., master at the Rossall School, Fleetwood.<sup>3</sup>

<sup>1</sup> The titles of these works, with the dates of the first editions, are as follows: *The Grounde of Artes*, 1541 (?); *The Castle of Knowledge*, 1551; *The Pathway of Knowledge*, 1551; *The Whetstone of Witte*, 1557.—EDITOR.

<sup>2</sup> W. F. Sedgwick, author of the article on Recorde in the *Dictionary of National Biography*, vol. 47, 1896, states that "the only known portraits of Recorde are woodcuts in the 'Urinal of Physick' and the 'Pathway to Knowledge.'" Consultations of copies of these works in the Library of Congress, in the Surgeon General's Library, Washington, in the Bodleian Library, Oxford, and in the Library of the British Museum, failed to reveal any such portraits. It is true that in the 1548 and 1567 editions of the *Urinal*, a cut two inches high by one and one quarter inches broad pictures the typical doctor. So also in the 1557 edition of the *Pathway* there is a figure (1 x  $\frac{1}{2}$  inch) of a student at his desk in the letter, G, of the word geometry. Although such cuts have not uncommonly been treated as portraits, Mr. A. W. Pollard of the department of printed books in the British Museum writes concerning the cuts here: "I do not think that there is any reason whatever to treat any of them as a portrait of Record." Hence the portrait published in connection with Professor Smith's article is probably the only existing portrait of Recorde.—EDITOR.

<sup>3</sup> It will also appear in the writer's forthcoming *History of Mathematics*, volume 1, together with the facsimile of the *probatum* of the will mentioned below.

It has not heretofore been published, but it was used as a basis for the bas-relief upon Recorde's monument at Tenby.

When J. O. Halliwell wrote his *Connexion of Wales with the early science of England* (London, 1840) he embodied a number of statements which, owing to his authority in matters of English History, have been generally accepted, and which were apparently relied upon in the preparation of the article on Recorde in the *Dictionary of National Biography*. Among these are the statements that Recorde's will is in the Prerogative Office and that it was dated June 28, 1558. A search for the will reveals the fact that it is only the official copy that is preserved, and that this has no date. The will was proved, as the facsimile of the official record shows, on June 18, so that Recorde must have died before that date. The *Probatum*, in reduced facsimile, is as follows:

The image shows a facsimile of a handwritten legal document. The word "Probatum" is written in a large, decorative, and somewhat stylized script at the beginning of the first line. The rest of the text is written in a smaller, more regular cursive script. The text is arranged in several lines, with some words and phrases written in a smaller, more compact script. The overall appearance is that of a formal legal record from the 16th century.

Inasmuch as the will does not seem to have been previously printed, and is so frequently mentioned in articles upon Recorde, it is of sufficient interest and value to deserve publication. Since the official transcript is written in the legal hand of nearly four centuries ago, it is difficult to make out all of the letters, but the following copy is substantially correct:

[In the margin: T(estamentum) Roberti Recorde.] *In the name of god amen.*  
 Inasmuch as nothing is more certaine to man then deathe, and nothing more  
 vncertain, the houre and tyme thereof, therefore knowe yō [= that] mi<sup>e</sup> [Mr.?  
 me?] Robert Recorde doctor of physicke though sicke in bodye yet whole in  
 mynde thanckis be to god make my last will and testament in manner and  
 fourme following. ffirst I comitt my soule unto thandes [= the hands] of the  
 same allmighti god my only maker and redemer trusting by the merites of his  
 passion to be one of his electe in glorie foreur [= forever]. my bodye as receyved  
 from the earthe I bequeath thither again to be buried among other christians  
 according to the solempne vsage of the church, my temporal goods and chattalles  
 I ordre wille and dispoas in manner and fourme following. Secondly, I geve to  
 Arthure hilton vnderm'shall [= undermarshall] of the kings benche whereat I  
 now remayn prisonner xxd Item to his wife other xxd. Item to the gent [?] noix  
 [?]prisonners w<sup>t</sup> me xxxd. Item I give other xxd to the said Arthure hilton to  
 be by him distributed amonge thofficers according to his discreation. Item to  
 his wif to be distributed amonge her women vj s viij d. Item I give generally  
 to the common gaole of the saide prisonne xl s to be equally distributed amonge  
 the prisonners there. Item I give and bequeathe to myid [?] anone [?] mother  
 and to my father in lawe her husbände xx li. Item I give to my s . . nnte  
 (= servant) John xj li Item I give unto the children of John Battyn xl s to be  
 distributed at the discreation of their saide father. The residue of all my goods  
 and chattalles moveable and unmoueable reall and psonnal. I give and bequeath

unto my brother Richard Recorde and Robert Recorde his sonne my nephewe whome I make and ordayne my full and hole executorns to thende that they beside my funeralles of the same shall truly and faithfully pay my detts. Whiche are to Nicolas ffulythm [?]citizen and merchanntaill<sup>o</sup> [= merchant tailor] of London fiftie poundes to M<sup>r</sup> Battyn xl s [?].

Memorand<sup>o</sup> thatte saide testato<sup>r</sup> on the morrowe next after the making of his testa<sup>t</sup> aforesaide being then of his parfite mynde and memorye adding to the said testament gave and bequeathed to Alice and Rose Recorde daughters of the saide Richarde Recorde, and also unto Julian Raye all his vtensiles or householde stuff to be egallie diuided betwene them. Item he willed and diused that Nicolas Adames then being prisonner in the kinges bench shulde have all his bookes concerning the lawes of this Realme at the price of iiij li. Witnes hereunto Richard Corbett George Marten and Richard Thymylby.

The tradition that Recorde was imprisoned for debt is not borne out by any evidence that I have been able to find. A search in the King's Bench Records has thus far been unproductive. There seemed to be a chance to find some evidence of payments to him as royal physician, or as Comptroller of the mines, but this, too, has not materialized, and the Memoranda Rolls and the Exchequer records are equally barren of information. In the printed Privy Council Acts, however, there are various entries relating to him as Comptroller of Mints and Monies in Ireland. There are also several entries about him in the Irish State Papers, from which entries it may be inferred that he was imprisoned owing to some misdemeanor in connection with the mines in Ireland. There is also a mention of the will in the *Index of Wills Proved in the Prerogative Court of Canterbury*, (volume 2, p. 257, London, 1898), but it contains no information of particular value. These sources are given as possible aids to anyone who may be desirous of pursuing the interesting historical investigation further. It may be added that Recorde was not Comptroller of the Mint at Bristol, as is often asserted; but the official documents show that this office was held by one Richard Recorde, presumably the brother who is referred to in the will. The statement that Recorde died "probably not long after making his will, June 28, 1558" (as in the *Dictionary of National Biography*) is also incorrect. The "XVIII" of the Probatum was probably read "XXVIII" by Halliwell or some earlier writer, and the error has been repeated by later biographers.

#### EDITOR'S BIBLIOGRAPHICAL NOTE.

The article on Robert Recorde in the *Dictionary of National Biography*, volume 47, 1896, contains nearly forty references to various writings dealing with his life and works. The following additional references may be given:

- M. Cantor, *Vorlesungen über Geschichte der Mathematik*, vol. 2, 2d ed., Leipzig, 1900, pp. 477-480, 552, 608, 621, 721, 791.
- G. Eneström, "Sur l'algèbre de Robert Recorde (1546)," *Bibliotheca Mathematica*, 1901, series 3, vol. 2, p. 152.
- G. Wertheim, G. Eneström, F. Amodeo, *Bibliotheca Mathematica*, series 3, vol. 3, 1902, p. 117; vol. 7, 1907, p. 290; vol. 8, 1908, p. 407.

- J. Knott, "Robert Recorde, a pioneer mathematician, astronomer, and physician," *Indian Medical Record*, Calcutta, 1904, vol. 25, pp. 1-3.
- D. E. Smith, *Rara Arithmetica*, Boston, 1908, pp. 213-221, 253, 286-288. [Title pages of *The Ground of Artes*, 1558, and *The Whetstone of Witte*, 1557, are here reproduced; also pages from these works showing counter reckoning and the explanation of the use of the sign for equality].
- H. Zeitlinger and H. C. S., *Bibliotheca Chemico-Mathematica*, Catalogue 682 of Henry Sotheran & Co., London, 1908, p. 197; (also in *Bibliotheca Chemico-Matematica*, vol. 1, London, 1921, p. 197. There is here, opposite page 200, a facsimile page from *The Castle of Knowledge*, the first English work recognizing the Copernican system.)
- L. C. Karpinski, "The Whetstone of Witte (1557)," *Bibliotheca Mathematica*, 1913, series 3, vol. 13, pp. 223-228.
- J. Knott, "Robert Recorde," *Nature*, Dec. 7, 1916, vol. 98, p. 268, see also p. 172.
- F. P. Barnard, *The Casting-Counter and the Counting-Board. A Chapter in the History of Numismatics and Early Arithmetic*. Oxford, 1916, pp. 254-266.
- F. Cajori, *History of Elementary Mathematics with Hints on Methods of Teaching*. Revised and enlarged edition. New York, 1917, pp. 183-188; numerous other page references are given in the index.
- F. V. Morley, "Finis coronat opus," *Scientific Monthly*, 1920, vol. 10, 306-308.

## ON A DIOPHANTINE PROBLEM.

BY O. D. KELLOGG, Harvard University.

Professor Carmichael has been kind enough to take an interest in, and give some currency to, a problem in Diophantine analysis which I communicated to him some years ago.<sup>1</sup> I stated to him at that time that the maximum value of any of the unknowns that can occur in a solution in positive integers of the equation

$$\frac{1}{x_1} + \frac{1}{x_2} + \dots + \frac{1}{x_n} = 1 \quad (1)$$

was  $u_n$ , where  $u_1 = 1$ , and

$$u_{k+1} = u_k(u_k + 1). \quad (2)$$

His remark, in the review cited, that a complete theory of this equation seemed desirable stimulated me to attempt to reconstruct the proof of my statement, which proof I do not seem to have preserved. The attempt, however, has given rise to a doubt in my mind as to my ever having had a really valid proof, but at the same time to confirm my belief in the accuracy of the statement.

It therefore seems to me proper to make the above confession to such of the readers of the MONTHLY as may have taken an interest in the problem, and to tell what I do know about it, for it has some rather nice aspects. Diophantine problems have at least the conspicuous merit that many phases of them are quite intelligible without profound knowledge of analysis, and for that reason are frequently a stimulus to mathematical interest.

The problem arose in connection with the familiar mapping of the surface of a triangle in the  $z$ -plane upon the upper half of the  $w$ -plane by means of an analytic function of a complex variable,  $w = f(z)$ . If the mapping is extended by

<sup>1</sup> See his *Diophantine Analysis*, New York, 1915, p. 115; also his review of Dickson's *History of the Theory of Numbers*, vol. 2, in this MONTHLY, 1921, 77.